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The Adult Feeding Habit of Some Conifer-infesting Weevils

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During the course of examining a white pine tree on May 25, 1945, the writer noticed a small black weevil clinging to the sheath of a needle fascicle, on the current year's shoot. The weevil was in a position parallel to the fascicle, its head directed upward, and its beak resting against the needle sheath. Closer scrutiny revealed a droplet of resin about the tip of the beak, and several small holes in the sheath distal to the beetle. When the beetle was removed, it was in the act of boring another similar hole in the needle fascicle. A brief search resulted in the finding of additional weevils in the same position on other twigs. Since no weevil of this habit on pine could be called to mind, six specimens were collected and two more were taken on May 29.

One of the specimens was tentatively identified as *Magdalis austera* Fall, but the others were not keyed out at that time. At a later date, all of the specimens were referred to Dr. Carl Parsons of our staff for verification. Dr. Parsons¹ found that three of the weevils taken on May 25 were *M. austera* Fall, as were the two specimens collected on May 29. The remaining three specimens collected on May 25 were identified as *M. hispoides* Lee. Mr. Charles Frost of Framingham, Mass., subsequently confirmed this opinion. Although these species apparently occur across the northern range of the United States and southern Canada, *M. hispoides* has not been recorded previously from Connecticut. Only the variety *substriga* of *M. austera* has been taken here in past years on pine.

The larvae of the conifer-infesting species of *Magdalis* occasionally are borers in the stems of young trees, but more usually in the twigs and branches of older trees (Escherich 8; Escherich and Baer, 9; Keen 12; Trägårdh, 16). Escherich considers these beetles to be of secondary importance, "since they attack only such plants which have been injured by fungi, other insects, and so forth, or already are dying." According to Trägårdh, however, young pine plantations sometimes are attacked by *M. violacea*, but only when these are in the vicinity of clear-cut areas on which the brush and tops furnish abundant breeding material.

The insect overwinters in the host plant in the larval form. Pupation and emergence of the adult beetles occur during late spring and early summer. Keen states that "the adults feed on the foliage and make punctures in the twigs of conifers and broadleaved trees, in which eggs are deposited." According to Escherich, "they live for several months, during which time they feed partly on their brood-plant (on bark and shoots), partly on other plants (on leaves)." Escherich and Baer further state that the adults of *M. frontalis* Gyll. feed on the bark of pine twigs, chiefly those of the previous year, but later also on the young May-shoots. Single, small holes were made, which were likened to the feeding holes of *Pissodes notatus* F. These authors also offered birch foliage to *frontalis*, but the beetles (which breed in pines) refused it. At the same time *M. violacea*, which breeds chiefly in spruce and more infrequently in pine, accepted birch foliage. This latter species apparently only feeds on birch, skeletonizing the leaves.

Observation of the feeding habit of *M. austera* and *M. hispoides* revealed some rather interesting facts. The adult beetle emerges at a time when the young

¹Now at the University of Vermont.

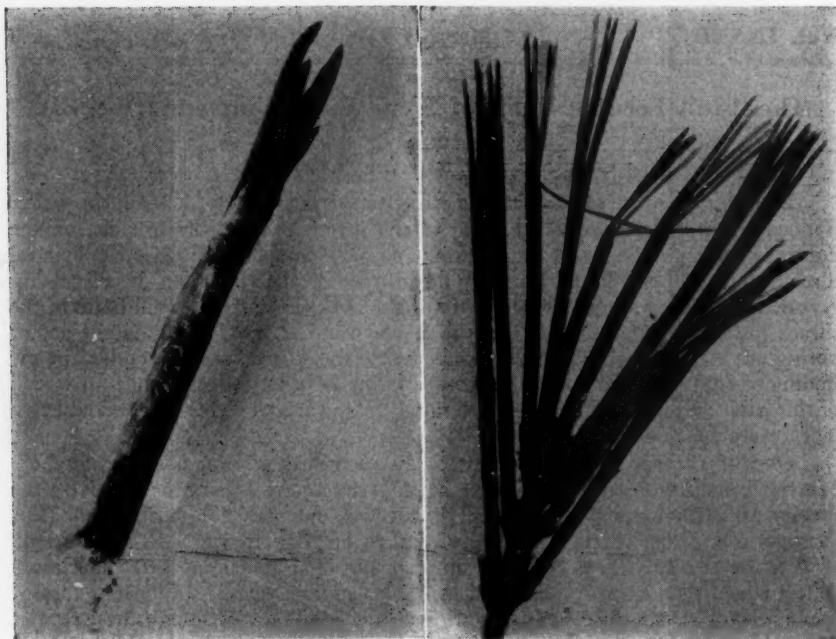


FIG. 1. Punctures made by *Magdalis* spp. through needle sheath of white pine; early growth stage; 5X.

FIG. 2. Kinking and yellowing of needles distal to point of feeding injury; later growth stage; 2X.

pine needles are just emerging from the needle sheath. When ready to feed, it assumes the position previously outlined, and appears to favor the inner side of the needle fascicle, that is, the side nearest to the central bud cluster. It then drills through the needle scales into the succulent young needles, in which it feeds. The beetle starts near the top of the needle fascicle and works downward, toward the base, making a series of holes therein (Figure 1). The number of needles affected per fascicle varies from one to all five, but usually the latter number.

The portion of the needle distal to the feeding wound turns yellow and gradually bends down at the point of injury. The appearance of such needles is shown in Figures 2 and 3. Pine needles grow from the base, and it will be noticed that the injured portion has been advanced considerably beyond the ends of the needle scales.

Still later in the growing season, the distal, dead part of the needle breaks off (Figure 4). Needles which have been so injured then appear to have been fed upon by a lepidopterous or sawfly larva (Figure 4). The writer frequently has seen this type of injury, but has always considered it to be caused by one of the above-mentioned larvae. Errors thus might easily be made during surveys for the presence of one of these latter forest pests. Close examination of the tip of an injured needle will show that it has not been eaten off, however. The appearance of the needle at the point of breakage is quite different from one which has been actually chewed off.

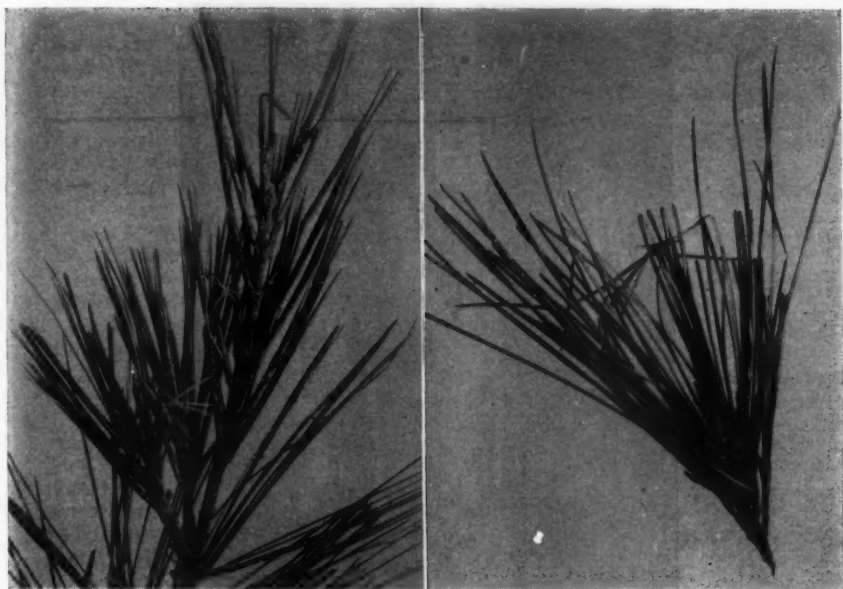


FIG. 3. Same as Fig. 2; natural size.

FIG. 4. Needles from which injured sections have broken off; advanced growth stage; 1.5X.

Another indigenous weevil, *Cylindrocopturus eatoni* Buchanan, also feeds in the needles of its host trees. Eaton (6) gives an excellent account of the biology of this insect, and figures the adult feeding habit. According to him, damage is caused by both larvae and adults to young trees between one and three feet high. The adult chews through epidermis, making a hole about 1.0 mm. in diameter; then eats out the mesophyll tissue beneath and peripheral to the hole through which the beak is inserted. In exceptional cases, the feeding injury to the needles is so extensive as to cause the death of the tree. The weevil also feeds on the tissues of the new twigs, and this type of injury, plus that to the needles frequently causes flagging of individual shoots.

A somewhat similar feeding habit is possessed by two different European weevils. One of these, *Brachonyx pineti* Payk. (*indigena* Hbst.) is called the pine-sheath snout beetle (Eckstein, 7; Escherich, 8). It is so named because the egg is laid in a hole bored in the innerside of one needle, just as the needles are emerging from the sheath. The larva, in feeding, makes at first a tunnel, later an open groove, which then is matched by a similar groove also eaten in the opposite needle of the pair (in two-needled pines). Movement of the larva is always toward the needle base; thus, always within the sheath. The adult beetle, to feed, makes a small, round hole in a needle, at some point above the sheath, inserts the proboscis, and feeds to the length of this organ. The needle, above this point, becomes discolored and later usually breaks off.

A second weevil which feeds in this manner is *Anthonomus varians* Payk, the pine flower borer (Escherich, 8; Lindemann, 13; Trägårdh, 16; Wichmann, 17). Wichmann gives a very complete account of the so-called nourishment-feeding (as opposed to the hole drilled for oviposition) of this species. He states that such feeding takes place almost exclusively on the needles of the current or



FIG. 5. Pine needles (probably Scotch pine) injured by nourishment-feeding of *Anthonomus varians*; taken from Trägårdh.

new shoot, only exceptionally on the needles of the previous year. The feeding puncture, according to him, is predominantly in the region of the needle sheath, and the beetle sinks its beak into the needle up to the eyes. The beetle always sits with its head toward the point of the needle, rarely slightly diagonally. "Thus, it eats beneath itself, backwards, a shallow cavity, whose extent and location is determined by the needle anatomy, the length of the beak and the position of the insect . . . only the assimilating tissue becomes consumed, . . ."

Trägårdh also has an excellent account of the feeding by *A. varians*. According to him: "The nourishment-feeding is characteristic, because the beetle makes a row of 6 to 8 roundish holes in the concave side of the needle (see Figure 5b and c, taken from Trägårdh), which on a mature needle always are found in the outer half. The result of this injury is that the tip of the needle first desiccates (c) and later falls off (a). Often one finds a quantity of such needles, and if one has not followed up the manner of damage, thus one can easily make the false assumption that the needles have been directly bitten off. If the needles are undeveloped, then one finds, on the other hand, the characteristic holes always in the basal part and in this case the needle becomes yellow and falls off."

It is most interesting that several different species embraced in four distinct genera should have the same rather unusual adult feeding habit. The host tissues in which the larvae feed and reach maturity also may differ with the genus. Needle injury by *Magdalis* spp. has not been observed to be extensive here, but may possibly occur in quantity under favorable conditions. According to Wichmann and others, adults of *A. varians* Payk. may occur in enormous numbers, although actual injury to the trees appears not to result from their feeding.

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The Cyto-taxonomy of Coleoptera^{1,2}

By STANLEY G. SMITH³

Introduction

As will be apparent, a study such as this serves a dual purpose in elucidating certain problems of phylogenetic relationships, either broad or narrow, and at the same time allowing the demonstration of the means by which the chromosomes themselves have undergone changes in their number, morphology, or

TABLE I
Distribution of Species, Genera, Families, and Superfamilies According to
Haploid Numbers of Autosomes*

HAPLOID NO.	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Total
Cicindelidae					2	5												7
Carabidae					1					1		1	4	1				8
Hydrophilidae										1	1							2
Silphidae		2						1			1				1			5
Staphylinidae								1	2						1		1	5
Lampyridae					7													7
Cleridae				2														2
Meloidae					3	1												4
Elateridae				6	9	8												23
Buprestidae				1	4	3	1	3										12
Dermestidae				4														4
Nitidulidae					1													1
Coccinellidae	2		1	6	10													19
Alleculidae					1													1
Tenebrionidae				2	4						1	2	1					10
Lagriidae		1																1
Melandryidae			1		1													2
Scarabaeidae	3				9	1												13
Passalidae								1										1
Cerambycidae					5	1												6
Chrysomelidae			2	3	2	5	5	1	2	2	2	6	1					31
Mylabridae					2			1										3
Curculionidae						22	1											23
Scolytidae										1								1
Species	5	3	4	24	61	46	7	8	4	5	5	9	6	1	2	0	1	191
Genera	3	2	4	16	40	20	4	7	4	5	5	7	6	1	2	0	1	127
Families	2	2	3	7	15	8	3	6	2	4	4	3	3	1	2	0	1	66
Superfamilies	2	2	2	6	8	6	2	5	2	4	4	2	2	1	2	0	1	51

*Excluding *Micromalthus debilis*, with haploid males.

mechanical properties, during the course of their phylogeny. That is to say, such lines of investigation have a direct appeal to both the taxonomist and the pure cytologist.

The original contributions made herein are based on a somewhat preliminary

¹Contribution No. 2668, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

²A condensed account of the central theme of a contribution to a symposium on taxonomy presented at the Eighty-sixth Annual Meeting of the Entomological Society of Ontario, Winnipeg, Manitoba, November, 1949.

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survey of slides made from about 750 specimens of beetles largely during the past six summers, contributions which, besides confirming or correcting many earlier determinations, have raised by some 65 the number of species known cytologically.

Diploid chromosome numbers among the 190 or so species now investigated range from a low of 12 to a high of 44, included among which, in males,⁴ are one, two, or more sex chromosomes, depending on whether they have a single X chromosome, an XY pair, or multiple sex chromosomes in their sex-determining mechanisms; that is, whether males and females respectively are XO:XX, XY:XX, or $X_1X_2Y:X_1X_1X_2X_2$, etc. From assessment of the frequencies of species possessing the various diploid numbers, the most prevalent and hence probably the most primitive condition in the order as a whole appears to be nine pairs of autosomes (non-sex chromosomes). This conclusion is further strengthened if, as in Table I, the distribution of the autosomal numbers is established according to genera, families, and superfamilies; for thereby any bias introduced by accidental or conscious selection in sampling is progressively reduced. For example, the six, nine, and eight species of elaterids with eight, nine, and ten pairs of autosomes respectively belong to only three, four, and three genera; or, again, the 22 weevils having ten pairs of autosomes fall into only five genera. On the other hand, the total of 31 species known cytologically in the Chrysomelidae belong to 25 different genera, as might in fact be expected in view of the extremely broad numerical range they cover.

By far the most frequent type of sex-determining system, whether upon the basis of species, genera, families, or superfamilies, is quite clearly the XY:XX (Table II). In fact, to the best of my knowledge the only families entirely devoid of an XY representative are the Lampyridae (XO:XX) and the monospecific Micromalthidae (haplo-diploid). Furthermore, in XY species the sex chromosomes show considerable variability: in size (relative to each other and the autosomes), in shape, in stainability, and in type of association during the maturation divisions. A consideration of the frequency of the various types in their distribution throughout the order shows that the typical form of the XY pair is one with the X about the size of the autosomes and a minute Y, both being V-shaped and associated during the maturation divisions at two terminal contact points in the form of a "parachute". On the basis of this admittedly much limited sample from only 25 families, a complex consisting of nine pairs of autosomes and a parachute XY sex pair is the predominant constitution (Table III) and is tentatively assumed to represent the primitive condition (formula $9AA + Xy_v$). The working hypothesis that deviations have been derived therefrom in the course of the evolution of the chromosomes is therefore formulated.

Leng's *Catalogue of the Coleoptera of America, North of Mexico* (1920), and supplements (1927, 1933, and 1939), has been followed in deciding questions of spelling. The conspectus of families in Leng (1920), which is based on Leconte, with modifications in accord with recent phylogenetic studies, has been followed herein because most non-specialists are more familiar with it.

Observations and Tentative Conclusions*

Adephaga

Caraboidea

Some uncertainty, due to difficulties inherent in the material, exists concerning the sex-determining mechanism in the Cicindelidae: Stevens (1906, 1909) regards the two species she examined as being simple XY:XX types, but Goldsmith

⁴Males of *Micromalthus debilis* Lec. are haploid (Scott, 1936); hence nothing is known regarding sex chromosomes in them.

*A detailed account of this work is in course of preparation and should soon be ready for publication. Thereafter, it is planned to attempt in a series of papers a complete analysis of the cytological bases for the various differences noted.

TABLE II

*Distribution of Sex-determining Mechanisms by Species, Genera, Families, and Superfamilies**

FAMILY	TYPE OF SEX-DETERMINING MECHANISM						TOTAL
	N/2N	Multiple	"XY"	XY	Xy	XO	
Micromalthidae	1						1
Cicindelidae					7		7
Carabidae		?		3	3	2	8
Hydrophilidae					1	1	2
Silphidae					3	2	5
Staphylinidae					5		5
Lampyridae						7	7
Cleridae					2		2
Meloidae					4		4
Elateridae				1	7	15	23
Buprestidae			1	4	5		10
Dermeestidae					4		4
Nitidulidae					1		1
Coccinellidae			2	1	15		18
Alleculidae					1		1
Tenebrionidae		5		1	4		10
Lagriidae				1			1
Melandryidae					2		2
Scarabaeidae			3		10		13
Passalidae					1		1
Cerambycidae					7		7
Chrysomelidae				2	21	6	29
Mylabridae					1	1	2
Curculionidae				1	16	2	19
Scolytidae					1		1
Total species	1	5	6	14	121	36	183
Total genera	1	1	4	12	78	18	
Total families	1	1	3	8	22	8	
Total superfamilies	1	1	3	5	14	7	

* Because certain species have been determined only in the female sex, it is not possible to assign the species to their sex-chromosome types; others are known only according to their sex chromosomes.

(1919), from a rather unsatisfactory study of one of Stevens' and four further species, is of the opinion that males have a large and a small X chromosome but no Y chromosome (XXxx in females). My observations, though somewhat limited to date and concerned with a species (*Cicindela repanda* Dej.; Fig. 1) distinct from those examined previously, appear to support Stevens' conclusion.

The carabids (Fig. 2), with the exception of one species, have been found to be characterized by high numbers ($2n=30-38$), and numerical change has evidently proceeded by (a) the separation of the "arms" of previously V-shaped chromosomes to form rods, thus increasing the number of separate elements; (b) loss of the y chromosome to give in two species an XO:XX sex-determining mechanism; and (c) fusion of the X and a rod-shaped autosome, that is, secondary

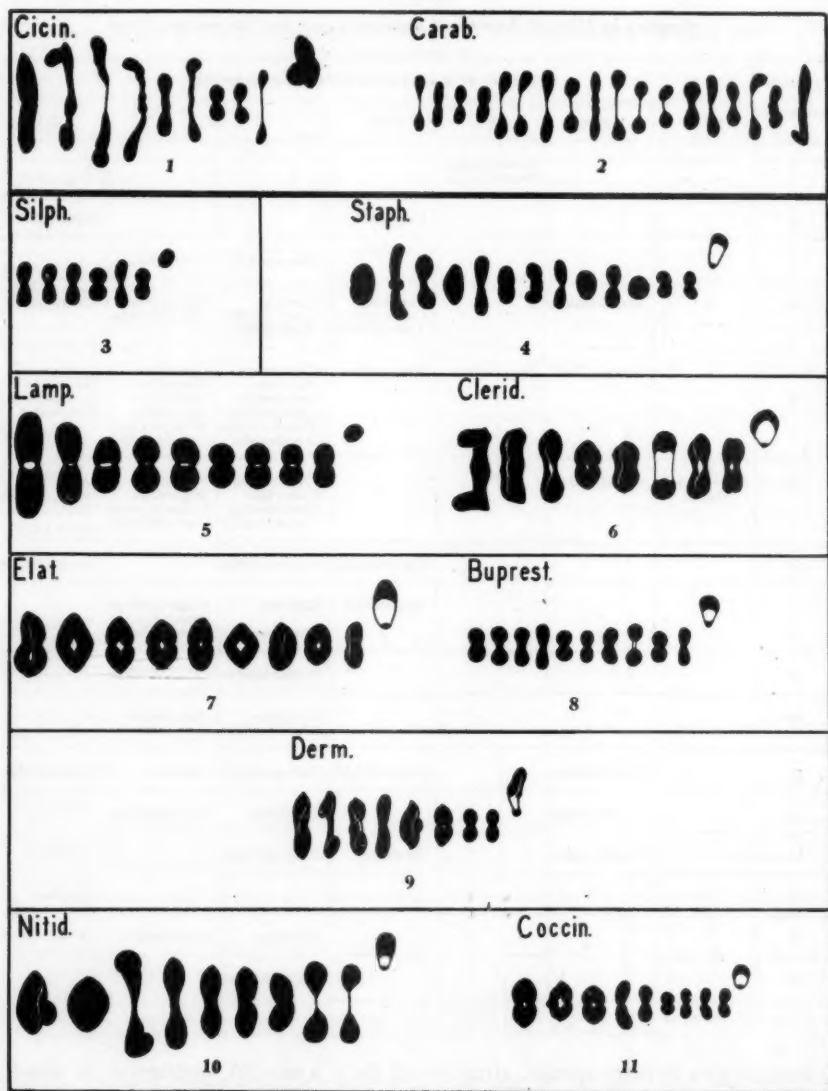
TABLE III

Families by Haploid Number of Autosomes and Sex-Chromosome Type

Haploid No. of autosomes	TYPE OF SEX-DETERMINING MECHANISM					
	N/2N	Multiple	"XY"	XY	Xy	XO
5			Coccinellidae Scarabaeidae			
6				Lagriidae		Silphidae
7					Chrysomelidae	Coccinellidae
8		Tenebrionidae		Elateridae Coccinellidae Tenebrionidae	Cleridae Coccinellidae Buprestidae	Dermestidae Chrysomelidae Elateridae
9		Cicindelidae?	Buprestidae	Buprestidae	Cicindelidae Meloidae Buprestidae Coccinellidae Tenebrionidae Scarabaeidae	Carabidae Elateridae Nitidulidae Alleculidae Melandryidae Cerambycidae Lampyridae Elateridae Chrysomelidae Myiabridae
10	Micromal- thidae	Cicindelidae?			Cicindelidae Elateridae Scarabaeidae Chrysomelidae	Meloidae Buprestidae Cerambycidae Curculionidae Elateridae Chrysomelidae Curculionidae
11				Curculionidae	Chrysomelidae	Chrysomelidae
12				Buprestidae	Silphidae Chrysomelidae	Staphylinidae Passalidae Myiabridae
13					Staphylinidae	Chrysomelidae
14					Carabidae Chrysomelidae	Hydrophilidae Scolytidae
15		Tenebrionidae		Chrysomelidae	Chrysomelidae	Silphidae Hydrophilidae
16		Tenebrionidae			Carabidae	Chrysomelidae
17		Tenebrionidae		Carabidae	Chrysomelidae	Carabidae
18						Carabidae
19					Silphidae	Staphylinidae
21					Staphylinidae	

fusion, to give in three species, after loss of the y a neo-XY mechanism in which both members are as large as, or larger than, the autosomes.

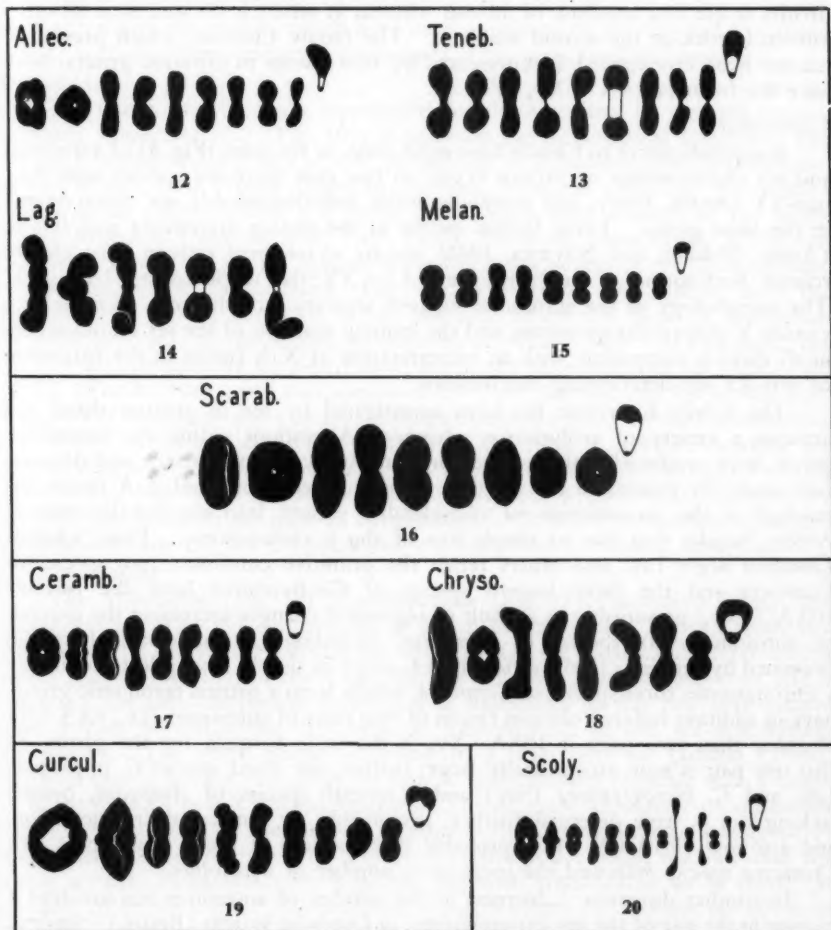
The one species which possesses the hypothetical primitive formula is *Chlaenius pennsylvanicus* Say (Stevens, 1906). It is worthy of note because the allied species *C. aestivus* Say has been found, also by Stevens (1906), to have a chromosome complement which may be expressed as $16AA + Xy$ —it is not clear from her illustrations whether the sex chromosomes are Xy_p . Such an extreme difference between a species as "close" as these is unknown elsewhere in the order, and, were it not vouched for by Stevens, would be regarded with justifiable scepticism.



FIGS. 1-11 First meiotic metaphases (redrawn and aligned) in males representative of various families—the sex chromosome or pair is placed consistently at the right. All drawings were made at an original magnification of $\times 6,600$; they are reproduced here at a magnification of $\times 4000$. Fig. 1. *Cicindela repanda* Dej.; Fig. 2. *Agonum cupripennis* Say; Fig. 3. *Necrophorus vespilloides* Hbst.; Fig. 4. *Nudobius cephalus* (Say); Fig. 5. *Pyractomena borealis* (Rand.); Fig. 6. *Thanasimus dubius* (Fab.); Fig. 7. *Limonius aeger* Lec.; Fig. 8. *Agrilus anxius* Gory; Fig. 9. *Anthrenus* sp.; Fig. 10. *Nitidula bipunctata* (L.); Fig. 11. *Hippodamia tredecim-punctata tibialis* Say.

*Polyphaga**Silphoidea*

The silphids, so far as examined, constitute two distinct cytological groups: two species of *Necrophorus* (Stevens, 1909; and Fig. 3 herein) have a low number of autosomes (12) and an XO:XX system in which the X chromosome is larger than the autosomes; species of *Silpha* are characterized by high autosomal numbers (24, 30, 38) and an X_y system.



FIGS. 12-20 First meiotic metaphases (redrawn and aligned) in males representative of various families—the sex chromosome or pair is placed consistently at the right. All drawings were made at an original magnification of $\times 6,600$; they are reproduced here at a magnification of $\times 4000$. Fig. 12. *Isomira quadristriata* Couper; Fig. 13. *Tenebrio molitor* L.; Fig. 14. *Aribromacra aenea* (Say); Fig. 15. *Serropalpus substriatus* Hald.; Fig. 16. *Serica tristis* Lec.; Fig. 17. *Monochamus notatus* (Drury); Fig. 18. *Anoplitis inaequalis* Web.; Fig. 19. *Sitona flavescens* Marsh; Fig. 20. *Ips* sp.

Staphylinioidea

The five known staphylinids (Fig. 4) resemble the species of *Silpha* in having high numbers (24-42 autosomes) and in their sex-determining mechanisms, as might be expected from consideration of their larval forms (Böving and Craig-head, 1931).

Cantharoidea

All male lampyrids examined by Stevens (1906, 1909) or me have the formula $9AA + X$ (Fig. 5) but differ in that in some species the X chromosome divides at the first anaphase of meiosis whereas in others it divides, as in all other known beetles, at the second anaphase. The family Cleridae, which previously has not been investigated, is represented by two species in different genera: both have the formula $8AA + Xy$, (Fig. 6).

Elateroidea

Buprestids native to Canada have eight, nine, or ten pairs (Fig. 8) of autosomes and sex chromosomes of various types: in one case there are species with Xy , neo-XY (Smith, 1949), and morphologically indistinguishable sex chromosomes in the same genus. Three Indian species in the genera *Sternocera* and *Julodis* (Asana, Makino, and Niiyama, 1942) are by cytological criteria very closely related: both species of the former are $12AA + XY$; that of the latter, $11AA + XY$. The morphology of the autosomes suggests separation of the arms of some previously V-shaped chromosomes, and the staining reaction of the sex chromosomes in all three is compatible with an interpretation of X-A fusion in the formation of neo-XY sex-determining mechanisms.

The family Elateridae has been investigated by me in greatest detail and presents a variety of evolutionary changes. Alterations within the autosomes, per se, have produced both increase (presumably by fragmentation) and decrease (obviously by fusion) in the number of separate elements; and X-A fusion has resulted in the introduction of considerable variety into the sex-determining system, besides that due to simple loss of the y chromosome. Thus, whereas *Limonium aeger* Lec. and others retain the primitive condition, two species of *Ctenicera* and the three known species of *Cardiophorus* have the formula $10AA + Xy$, presumably as a result of segmental changes increasing the number of autosomes. Six species of *Ampedus*, including two unidentified species examined by Stevens (1906), differ from *L. aeger* in simply having lost the minute y chromosome; three species of *Ctenicera*, which form a natural taxonomic group, have in addition suffered obvious fusion of two pairs of autosomes (i.e., $8AA + X$) or more than two pairs if $10AA + Xy$ is the basic formula for the genus—so that one pair is now exceptionally large; further, the allied species *C. p. propola* Lec. and *C. hieroglyphica* (Say) and a seventh species of *Ampedus*, besides lacking the y, have diverged further, presumably by autosomal fragmentation, and are now $10AA + X$. It is probable that the loss of the y from these two *Ctenicera* species followed the increase in number of autosomes.

In another direction, a decrease in the number of autosomes has involved a change in the size of the sex chromosomes: in *Limonium griseus* (Beauv.) (Stevens, 1909) and *C. appropinquans* (Rand.), fusion of the X and an autosome in conjunction with the loss of the homologue of the autosome concerned has given rise to the formula $8AA + \text{large-X}$; in an undetermined species of *Melanotus* the retention of the homologue provides the formula $8AA + \text{neo-XY}$. Finally, *C. splendens* (Zieg.) demonstrates an even more complex evolutionary history: its formula, $9AA + \text{large-X}$, points to X-A fusion in addition to autosomal fragmentation—conditions in the allied species, *C. appropinquans*, imply that the latter predated the former change.

From this brief account of the genus *Ctenicera*, it is obvious that the cytological demonstration of distinct groups of allied species characterized by the formulae $10AA + Xy_p$, $10AA + X$, $9AA + X$, and $8AA + X$ is consistent with the taxonomic evidence that the genus is readily divisible into a number of more or less natural groups.

Byrrhoidea

Of the four families comprising this superfamily none has been investigated hitherto. Herein four species in the genera *Dermestes* and *Anthrenus* (Fig. 9) have come under observation: all conform to the formula $8AA + Xy_p$. In this they agree with the clerids, which have been associated by Böving and Craighead (1931) with the Dermestidae as components of the superfamily Cleroidea.

Cucujoidea

The family Nitidulidae is represented for the first time, by a single species, *Nitidula bipunctata* (L.) (Fig. 10): it possesses the hypothetical formula. The family Coccinellidae consists of two subfamilies, Coccinellinae and Epilachninae; of the former, both North American (Stevens, 1906 and 1909; also the writer) and Japanese (Yosida, 1944 and 1948) species have been studied; of the latter, North American (Stevens, 1906; Hoy, 1918), European (Strasburger, 1936), and Japanese (Yosida, op. cit.). Species in the following genera of the Coccinellinae, *Adalia*, *Coccinella*, *Hippodamia* (Fig. 11), *Synonycha*, and *Calvia*, have the formula $9AA + Xy_p$ (or $9AA + Xy$, in cases where the type of association between the sex chromosomes is uncertain); *Anatis mali* (of authors) has $8AA + XY$, presumably by X-A fusion; *Harmonia axyridis* Pallas has $7AA + Xy$ or XY (Yosida, 1944); and two species of *Cleis* are characterized by having only five pairs of autosomes and a large, indistinguishable sex pair. In the Epilachninae, the North American *Epilachna borealis* (Fab.) and a hybrid between the European species *E. chrysomelina* F. and *E. capensis* Thunb. have the formula $8AA + Xy$, but three Japanese species have the hypothetical chromosome number, and a fourth has only 18 chromosomes. It is not certain from Yosida's publications how the sex chromosomes are associated at meiotic metaphase.

Tenebrionoidea

The Alleculidae (Fig. 12), Tenebrionidae (Fig. 13) (excluding *Blaps*), and Melandryidae (Fig. 15) conform to, or are in general clearly derived from, the primitive type (Stevens, 1909; also the writer). On the other hand, *Arthromacra aenea* (Say) (Fig. 14), in the Lagriidae, has only six pairs of autosomes and a large XY sex pair—segmental differences in stainability in this pair demonstrate that a pair of autosomes has become incorporated in the sex-determining mechanism. The genus *Blaps*, according to a brief note by Guénin (1949), includes species having two, three, or four X chromosomes together with a single Y in the male (4 to 8 X's in the female). The decrease in number of autosomes that in general parallels the increase in number of X chromosomes is suggestive: the Y may in fact be the X of a more primitive XO system, the so-called X's being actually autosomes with X-pairing segments translocated on to them. It remains to be seen what interpretation is put forward by Guénin on the basis of other considerations.

Scarabaeoidea

Apart from two species of *Phanaeus* (Hayden, 1925) and the European *Oryctes nasicornis* L. (Prowazek, 1902), the known members^a of the family Scarabaeidae have the formula $9AA + Xy_p$ (Fig. 16). These exceptional species, representatives of taxonomically well separated subfamilies, are similar cytologically in that they have only six pairs of chromosomes, among which the sex pair

^a*Geotrupes balyi* Jek. has $10AA + XY_p$: it falls into the Geotrupinae of Böving and Craighead (1931).

See also recent determinations by Yosida, 1949.

has not as yet been identified. A single species in the Passalidae has been reported (Shaffer, 1917) to possess the formula $12AA + Xy$: it is not at present possible to suggest how it may have arisen.

Cerambycoidea

All three families in this superfamily have been sampled. Cytologically the cerambycids conform in general to the primitive formula (Fig. 17) but one species, *Acmaeops proteus* (Kby.), out of the six known has ten pairs of autosomes, indicating fragmentation of one original pair. The family Chrysomelidae is obviously the most heterogeneous group, with diploid numbers ranging all the way from 16 to 36 and including XO , Xy , (Fig. 18), and XY (Yosida, 1944) systems in the male. The Mylabridae (=Bruchidae) remain unsampled by me, but all three mentioned in the literature are lesser ($9AA + X$) or greater ($12AA + Xy$) deviates from the primitive condition.

Curculionoidea

Twenty species in the Curculionidae have been examined to date; all but two, in the genus *Sitophilus*, have either $10AA + Xy$, or $10AA + XO$ males (Suomalainen, 1940 a and b, 1947; Mikulska, 1949; Fig. 19 herein). Several others are obligatory parthenogenetic species with $10AA + XX$, triploid, tetraploid, or pentaploid females^o (Suomalainen, op. cit.)—the absence of males precludes the possibility of assigning them to a sex-chromosome class.

The only diploid species reported to have other than ten pairs of autosomes are *Sitophilus granarius* (L.) [= *Calandra granaria* (L.)] and *S. oryzae* (L.) [= *Calandra oryzae* (L.)]; according to Inkmann (1933) and Tiegs and Murray (1938) females have the diploid number 12, and according to Gunson (1945) the male of *S. oryzae* has the diploid number 11. In addition to their reputed possession of such atypical chromosome numbers these species have been reported, after the works of Agar (1911), to be anomalous in chromosome behaviour also. Gunson claims that *S. oryzae* conforms to the formula $5AA + X$ in the male, but in preliminary examinations I find a probable formula of $10AA + XY$,⁷ and for *S. granarius* a formula of $11AA + XY$. The anomalies in behaviour that have been reported can be readily reconciled with these counts. Further, the differences in their chromosome complexes relative to those of species in other subfamilies are in agreement with the family rank conferred upon the Calendrinae as a result of the larval studies of Böving and Craighead (1931).

Scolytoidea

A single scolytid was found to have the formula $14AA + Xy$, (Fig. 20), the increase in number of autosomes apparently having resulted from separation of the arms of several chromosomes.

Conclusions

The primitive formula $9AA + Xy$, being accepted, the following evolutionary changes are indicated as having occurred within the chromosome sets of Coleoptera: decrease in the number of autosomes by either fusion of non-homologous autosomes or fusion of autosomes and the X chromosome, or both; and increase in number as a consequence primarily of autosomal fragmentation. Changes in the mechanism by which sex is determined have arisen either by simple loss of the minute y chromosome to give an $XO:XX$ system or by X-autosomal fusion to give on the one hand a neo-XY sex pair (if the autosomal homologue were retained) and on the other a neo-XO system (if it were lost).

Further changes, at present unexplained, have provided a haplo-diploid sex-determining mechanism in *Micromalthus debilis* and a series of multiple sex-

^oW. J. Brown has drawn to my attention the fact that Suomalainen's (1940a) Finnish bisexual species are, unlike some of his parthenogenetic species, not native to Canada.

⁷Pending confirmation, this determination is omitted from the tables.

chromosome systems in species of *Blaps*. Extreme variability in chromosome number and in type of sex-determining mechanism has been found; for example, that in the Chrysomelidae (as used herein) is in full agreement with its elevation to the rank of superfamily, accorded on the basis of Böving and Craighead's (1931) work on larval forms.

Acknowledgment

It is a pleasure to record my indebtedness to W. J. Brown, Systematic Unit, Division of Entomology, Ottawa, for his ready advice on matters of phylogenetic relationship and especially for undertaking the taxonomic determinations.

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The Bramble Leafhopper, *Typhlocyba tenerrima* H.-S. (Homoptera: Cicadellidae), A Destructive European Insect New to the Pacific Northwest¹

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In July, 1947, a leafhopper was found causing serious injury to the foliage of loganberries in the Brentwood area of Vancouver Island, B.C. A survey made at that time in southern Vancouver Island showed that this species was widely distributed, and that it occurred also on raspberries and blackberries. In 1948 it was again found injuring loganberries on Vancouver Island and was found also in the lower Fraser Valley; and in 1949 it was observed 40 miles north of Victoria, at Cowichan Bay, feeding on wild blackberry. It is probable that this species had been present in the coastal area of British Columbia for some time before it was first observed in 1947 causing economic damage.

Adult specimens collected during 1947 in the Victoria area were submitted to the Systematic Unit, Division of Entomology, Ottawa, Canada, and subsequently forwarded to Mrs. Dorothy J. Knull of Columbus, Ohio, U.S.A., who identified them as *Typhlocyba tenerrima* Herrich-Schaeffer. According to McAtee (1) this species was described from Germany in 1834, and has subsequently been recorded from many localities in Europe from Sweden to Italy and westward. It is known to occur in Great Britain, where it was described under the name of *Typhlocyba rubi* by James Hardy in 1850. In 1896 James Edwards reported it from a number of stations in the British Isles, and described it as "common on brambles".

In North America the species has been reported by Van Duzee (2) from Quebec, Ontario, Maine, New Hampshire, New York, Michigan, and Colorado; but McAtee (1), a recent reviser of the group, states that he has been unable to verify any of these records. In determining the Vancouver Island material, Mrs. Knull stated that these specimens were the first that she had studied that were in agreement with *T. tenerrima*. The remarks of these two writers seem to cast serious doubt on the validity of the previous American records for this species.

Life-History and Damage

On Vancouver Island, nymphs and adults produce white stippling upon the leaves of brambles throughout the growing season. The eggs, which overwinter in the canes, hatch during the first two weeks of May, and the young nymphs feed on the undersides of the newly developed leaves. The first generation completes its development on loganberries during the first two weeks of July, when loganberry harvesting has started. The nymphs of the second generation

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commence to injure the foliage on both old and new canes about mid-August. Adults of this generation are numerous on the new canes during the first two weeks of September and may be found feeding on the foliage as late as November.

The damage to the foliage is most severe during August and September, when leaves of both old and new canes have been attacked by adults of the first generation and nymphs of the second generation. The mature leaves that have been attacked by this leafhopper become devoid of chlorophyll, mottled-yellow in appearance, and concave or cup-shaped on the under surface. In southern Vancouver Island, where there is less than one inch of rainfall per month during June, July, and August, this severe damage to the foliage seriously affects the development and size of the fruit and the growth of new canes. If the leafhopper infestation is severe, the fruits develop to only about half their normal size and fail to mature.

Control

Experiments were conducted by officers of the Dominion Entomological Laboratory at Victoria during 1948, when sprays were applied to a 10-year-old blackberry planting in the Keating area. One application of the spray material was made about mid-May, when the fruiting arms were four to six inches long. A Dobbins power sprayer, fitted with a $3/64$ -inch nozzle in the spray gun, was used to apply approximately 100 gallons per acre at 200 pounds pressure.

Results (Table 1) were recorded during the second week in July, when the first generation of leafhoppers had completed their development. In each plot 1500 leaves were examined, and the percentage that showed any leafhopper injury was recorded.

TABLE 1
Effectiveness of spray materials in controlling nymphs of *Typhlocyba tenerrima* on blackberry foliage

Materials per 100 gallons	Percentage of leaves showing leafhopper injury
25% Parathion, 1 lb.	9.7
50% DDT, $1\frac{1}{2}$ lb.	12.0
Lime-sulphur, $2\frac{1}{2}$ gal.	13.5
40% Dinitrocyclohexylphenol, 5 oz.	24.6
50% Hexaethyltetraphosphate, $\frac{1}{4}$ pint	53.4
Check	100.

Table 1 indicates that 50 per cent DDT, $1\frac{1}{2}$ pounds, or 25 per cent parathion, 1 pound, per 100 gallons, gave very satisfactory control of the leafhopper nymphs without being phytotoxic to the foliage. Lime-sulphur and dinitrocyclohexylphenol showed promise of controlling the nymphs but caused damage to the blackberry foliage. Although 9 to 14 per cent of the leaves were injured by leafhoppers when DDT, parathion, or lime-sulphur was used, the extent of the injury was actually insignificant in each case. The only leafhopper damage of economic importance occurred in the hexaethyltetraphosphate and the check plots. The spray injury from the dinitro material appeared as chlorotic yellow and brown lesions between the veins of the leaves, whereas that from the lime-sulphur showed characteristic yellow and brown lesions along the margins of the leaves.

Most of the loganberry and raspberry growers in the lower Fraser Valley have been using a three per cent DDT dust in a two-application program, the first being made during the first two weeks of May, or when the blossom buds are separating in the cluster; and the second, three weeks later or immediately prior to blossom. This program has controlled both the leafhopper and the western raspberry fruitworm, *Byturus bakeri* Barber, without the serious increase

in the population of some mites that has developed in other areas after the use of DDT.

Where blackberry growers applied lime-sulphur as a control for leafhoppers, the redberry mite, and septoria leaf spot, good results were obtained with two sprays, namely, 10 gallons of lime-sulphur per 100 gallons of water in the dormant period, followed by two gallons per 100 gallons of water when the fruiting arms were six to eight inches long. The amount of foliage injury caused by the lime-sulphur was apparently of no great consequence.

Acknowledgment

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New Leadership in the Canadian Division of Entomology

The Division of Entomology in the Canadian Department of Agriculture is now one of the largest entomological services in the entire world, second only to the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture. Its staff now comprises over 300 professional officers and its annual budget is in the neighborhood of \$3,000,000. Entomology, in such settings is, in the main, economic entomology: ancillary to agriculture. Pursuing this idea to what seems its logical conclusion, the authorities in some parts of the world have attempted, sometimes with success, to break up the entomological body into a collection of subordinate units, each working under more or less specialized agricultural direction; so that the entomologist becomes a member of an agricultural team, concentrating on some special objective. Such arrangements are fairly common in the old world. Outstanding examples in Great Britain are the Horticultural Research Station at East Malling and the Agricultural and Horticultural Research Station at Long Ashton.

Entomologists, as a rule, dislike such arrangements. This is not because they object to the overall direction of agriculturists or are essentially uncooperative. It is because they feel that the stimulus derived from association with other entomologists working as a scientific corporation under a recognized leader in this field of endeavor, is of far greater benefit to their work, than the directional impetus involved in team-work. Economic entomology is in a very profound sense a derivative of pure entomology and pure entomology is a perfectly definite branch of zoology, specified by its object: the insects. The study of this vast group, highly diversified in its structure and habits, existing in every type of the terrestrial environment, cannot be regarded as a narrow specialism. The pioneer researches of Fabre on instinct, the great work on heredity founded by Morgan, the philosophical controversies of Wassmann and Wheeler are all entomological developments. To detach entomologists, even enrolled in the service of agriculture, from the scientific traditions to which the entomological corporation is heir is, we believe, a serious administrative error. On the other hand, many agricultural problems cannot be solved without a coordinated effort in

which entomologists participate. We understand that the scientific service of the Department of Agriculture is following a policy in which officers representing the various scientific disciplines will be grouped in well-equipped research centres where they can work in coordination on certain special problems; but that the specialists of each group will remain under the scientific direction of their own professional chiefs. This strikes us as an admirable arrangement.

Since its foundation in 1883 under Dr. James Fletcher, the Federal Entomological Service, under the direction of a series of capable successors, has developed into a vast organization working all over Canada on an immense variety of problems. It is clear that the direction of such a service requires not only organizing ability and physical stamina, but the understanding of scientific principles and modern research methods that can only be gained by intensive work on concrete entomological problems. We cannot agree with those who say that great scientific services can best be managed by mere administrators. Scientific men subject the qualifications of their professional superiors to keen scrutiny. They work best under chiefs whose scientific attainments they are obliged to respect. Furthermore, they have a tendency, with which the pure administrator cannot easily cope, to wander away on primrose paths unlikely to lead to any practical goal, justifying this by arguments an outsider cannot easily answer. To control and coordinate without either damping initiative and originality or allowing freedom to generate anarchy, is no easy task. The change in the leadership of the Division of Entomology that has occurred with the retirement of Mr. H. G. Crawford and the appointment of Dr. Robert Glen, is therefore of great importance to entomologists everywhere.

Dr. Robert Glen, the new Dominion Entomologist, was born in Paisley, Scotland, on June 20, 1905 and moved to Canada with his parents about 1912. He entered the college of Arts and Sciences of the University of Saskatchewan in 1926, graduating with honours in biology in 1929. In 1931 he obtained his M.Sc. degree from the same university, specializing in entomology. Further graduate studies were undertaken in the University of Minnesota on the Caleb Dorr Fellowship for 1931-32 and the Shevlin Fellowship for 1932-33. The thesis for the Ph.D., awarded by the University in Minnesota in 1940, was completed during the intervening period. In 1929 Dr. Glen was appointed to the staff of the Dominion Entomological Laboratory, Saskatoon, Saskatchewan, where from 1935 to 1945 he was in charge of wireworm control research under Mr. K. M. King. In 1945 he was transferred to Ottawa as Research Coordinator and on February 15, 1950 was appointed as Dominion Entomologist.

Dr. Glen's research work has been mainly concerned with the section of the family Elateridae commonly known as wireworms: a group of great economic importance but notoriously difficult to control. His published papers and mimeographed reports, which represent, we believe, only a fraction of what he has accomplished indicate a remarkable versatility. Though the research has extended far into the pure scientific field, it is all logically connected with the problem of control. As the economic work in wireworms developed, it was found that many react differently to weather, soil and cultural methods. The recommendations for control therefore depend on the species concerned. But wireworms develop slowly, often requiring several years to mature. It is therefore necessary to identify them in the larval stage. To produce accurate and trustworthy keys for identification, minute and comprehensive studies are necessary: minute, so that all the available characters will be utilized; compre-

hensive, so that their significance in determination and taxonomy can be properly understood.

We cannot attempt, in this short notice, to evaluate adequately the results of these studies. In the practical field they have led, we understand, to the development of control measures that are really effective. Their scientific results have appeared in a number of papers, culminating in the fine 246-page monograph published by Dr. Glen as Vol. 111, No. 11 of the Smithsonian Miscellaneous Collections under the title: "Larvae of the Elaterid beetles of the tribe Lepturoidini (Coleoptera: Elateridae)". In this work Dr. Glen has treated the larvae of 93 species, distributed among 11 genera. Forty plates containing a large number of clear and well-executed figures, illustrate the paper.

The Editor of *The Canadian Entomologist* has not worked on Coleopterous larvae. He has however, made extensive studies on the larvae of the parasitic Diptera from a viewpoint and with an objective very similar to that of Dr. Glen. He feels safe in saying that the monograph of the Lepturoidini will be regarded as one of the standard treatises on the larval stages of the Coleoptera. It shows throughout evidence of the hard, detailed, painstaking work which can alone lead to results of permanent value.

We offer to Dr. Glen our sincere congratulations on his appointment and we wish him success in the important work for which he has been chosen.

W. R. THOMPSON

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